Missouri Department of Natural Resources

Biological Assessment and Channel Evaluation

Hickory Creek and Hickory Creek Tributary
Grundy County, Missouri

Fall 2006 - Spring 2007

Prepared for:
Missouri Department of Natural Resources
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1.0 Introduction

The headwaters of Hickory Creek originate in Grundy County, Missouri approximately six to ten miles west of Trenton, Missouri (Figure 1). The stream is approximately 15 miles long with several intermittent tributaries. The watershed contains approximately 17,664 acres at its confluence with the Thompson River approximately seven miles south of Trenton.

Hickory Creek [Water body #588] and Hickory Creek Tributary (hereafter called Tributary) [Water body #589] are listed as class C streams with Designated Beneficial Uses for livestock and wildlife watering (**LWW**); protection of warm water aquatic life and human health-fish consumption (**AQL**); and whole body contact (**WBC**), category B (MDNR 2005c). Class "C" streams may cease flowing in dry periods, but maintain permanent pools which support aquatic life. The WBC "category B" applies to waters designated for whole body contact recreation not contained within category A, which states: "those water segments that have been established by the property owner as public swimming areas allowing full and free access by the public for swimming purposes and waters with existing whole body contact recreational use(s). Examples of this category include, but are not limited to, public swimming beaches and property where whole body contact recreational activity is open to and accessible by the public through law or written permission of the landowner" (MDNR 2005c).

Hickory Creek is a unique small prairie stream in north central Missouri. It is one of only a few streams in Grundy County that has not been channelized and is also habitat for the federally and state-listed endangered Topeka Shiner (*Notropis topeka*), which was collected in the mid 1990s (NRCS 2005; MDC 2008).

1.1 Justification

Approximately seven miles of Hickory Creek and one mile of Hickory Creek Tributary, Grundy County are on the Missouri Department of Natural Resources 2002 list of impaired waters, under section 303(d) of the Federal Clean Water Act. The streams are listed for unknown pollutants with a medium priority for analysis (MDNR 2004). Potential for water quality problems are present in the Hickory Creek watershed (NRCS 2005; MDC 2008). Approximately 3772 acres (21 percent) of the watershed are highly erodible land, which may contribute to sedimentation and loss of habitat in the stream. Other agricultural practices can contribute to nutrient enrichment and high summer temperatures and may contribute to low dissolved oxygen levels in Hickory Creek (NRCS 2005; MDC 2008).

The Hickory Creek and Tributary biological assessment and channel evaluation was conducted at the request of the Missouri Department of Natural Resources (**MDNR**), Water Protection Program (**WPP**), Water Pollution Control Branch (**WPCB**). The Environmental Services Program (**ESP**), Water Quality Monitoring Section (**WQMS**), Aquatic Bioassessment Unit (**ABU**) coordinated and conducted the study.

1.2 Purpose

Determine if Hickory Creek and/or Tributary are impaired.

1.3 Objectives

1) Assess the stream habitat quality of Hickory Creek.

2) Assess the macroinvertebrate community integrity and water quality of Hickory Creek and Tributary

3) Determine if Hickory Creek and Tributary exhibit channelization characteristics.

1.4 Null Hypotheses

1) Stream habitat is similar between stations of Hickory Creek and Tributary from upstream to downstream and with the control.

2) Macroinvertebrate communities are similar between reaches of Hickory Creek and Tributary from upstream to downstream and to the biological criteria index scores.

3) Water quality is similar from upstream to downstream and within acceptable water quality standards (**WQS**; MDNR 2005c).

4) Channel width, depth, and sinuosity measures are similar between reaches of Hickory Creek from upstream to downstream and to East Fork Grand River and West Fork Big Creek (controls).

2.0 Methods

Kenneth B. Lister (ESP), Brian Nodine (ESP), and staff of the WQMS conducted this study. Methods are outlined in this section. The study timing is outlined. The study area and station descriptions, Ecological Drainage Units (**EDUs**), and land uses are identified. Biological assessment procedures, which include macroinvertebrate community and physicochemical water collection and analyses, are discussed.

2.1 Study Timing

Sampling was conducted in the fall of 2006 and the spring of 2007. The fall stream habitat assessments, biological assessments, and channel measurements were conducted at Hickory Creek stations #3 and #2 on September 19, 2006 and at station #1 on September 21, 2006. Tributary was not sampled in the fall due to no flow, very little standing water, and little habitat. Stream habitat assessments were conducted at East Fork Grand River #1 and West Fork Big Creek #1 on September 26, 2006. Channel measurements from these streams were recorded in the fall of 2004, sample numbers 0418767 and 0418766, respectively.

The spring biological assessments were conducted at all Hickory Creek stations on March 27, 2007. Water was present and flowing in Tributary and a biological assessment was conducted on March 28, 2007.

2.2 Study Area and Station Descriptions

The study area included 8 miles of 303(d) listed stream segments (Figure 2). Three stations were allocated for the Hickory Creek study. Tributary had no habitat in the fall, so it was not included with the sample stations. Hickory Creek #3, upstream of the Tributary confluence, was sampled as an upstream control to bracket potential influence. Habitat was available in Tributary during the spring and a station was included for study (Table 1; Figure 2).

Table 1
Location and Descriptive Information for Hickory Creek and Tributary, Grundy County; East Fork Grand River, Worth County; and West Fork Big Creek, Harrison County 2006-2007

Stream-Station Number	Location-Section, Township, Range Latitude and Longitude	Description	County
Hickory Creek #3	NE ¼ sec. 16, T. 60 N., R. 25 W. Lat. 40.017830 Long. -93.717270	Downstream bridge Hwy WW	Grundy
Hickory Creek #2	SW ¼ sec. 24, T. 60 N., R. 25 W. Lat. 39.999390 Long. -93.668300	Downstream bridge County Road SW 54th in Hickory, MO	Grundy
Hickory Creek #1	NE ¼ sec. 29, T. 60 N., R. 24 W. Lat. 39.988220 Long. -93.622190	Approximately 1.5 miles downstream Hwy W	Grundy
Tributary	sec. 15/16, T. 60 N., R. 25 W. Lat. 40.01840 Long. -93.708300	Downstream culvert bridge Hwy WW, approx. 0.5 mile east of #3	Grundy
East Fork Grand River #1 (SHAPP)	NW ¼ sec. 32, T. 66 N., R. 30 W. Lat. 40.481390 Long. -94.318620	Downstream bridge MO Hwy 46	Worth
West Fork Big Creek #1 (SHAPP)	SW ¼ sec. 15, T. 65 N., R. 28 W. Lat. 40.425940 Long. -94.038600	Upstream bridge County Road 180, 1.2 miles east of Hwy W	Harrison

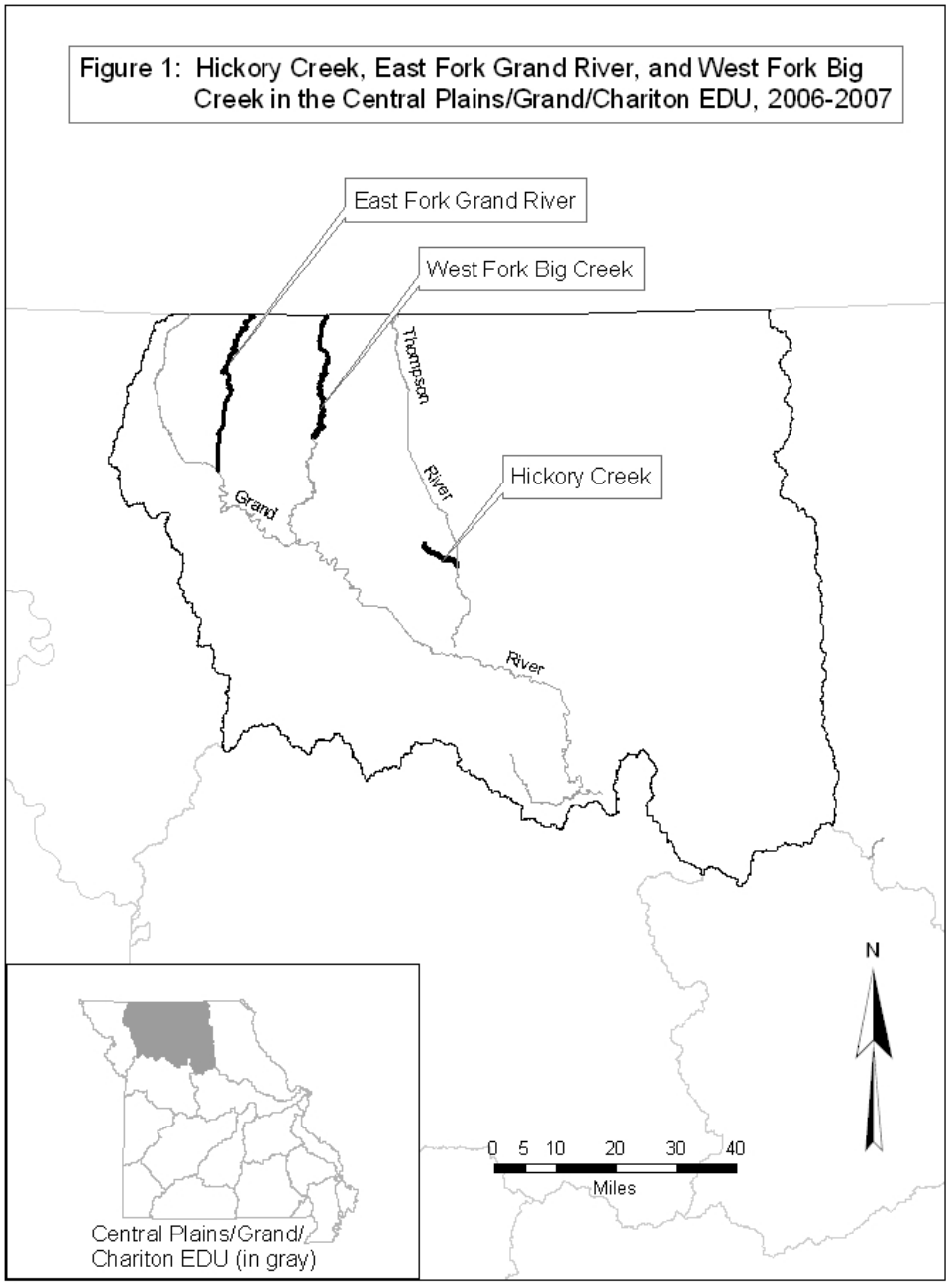
Figure 1: Hickory Creek, East Fork Grand River, and West Fork Big Creek in the Central Plains/Grand/Chariton EDU, 2006-2007
East Fork Grand River
West Fork Big Creek
Thompson
River
Hickory Creek
Grand
River
N
0 5 10 20 30 40
Miles
Central Plains/Grand/
Chariton EDU (in gray)

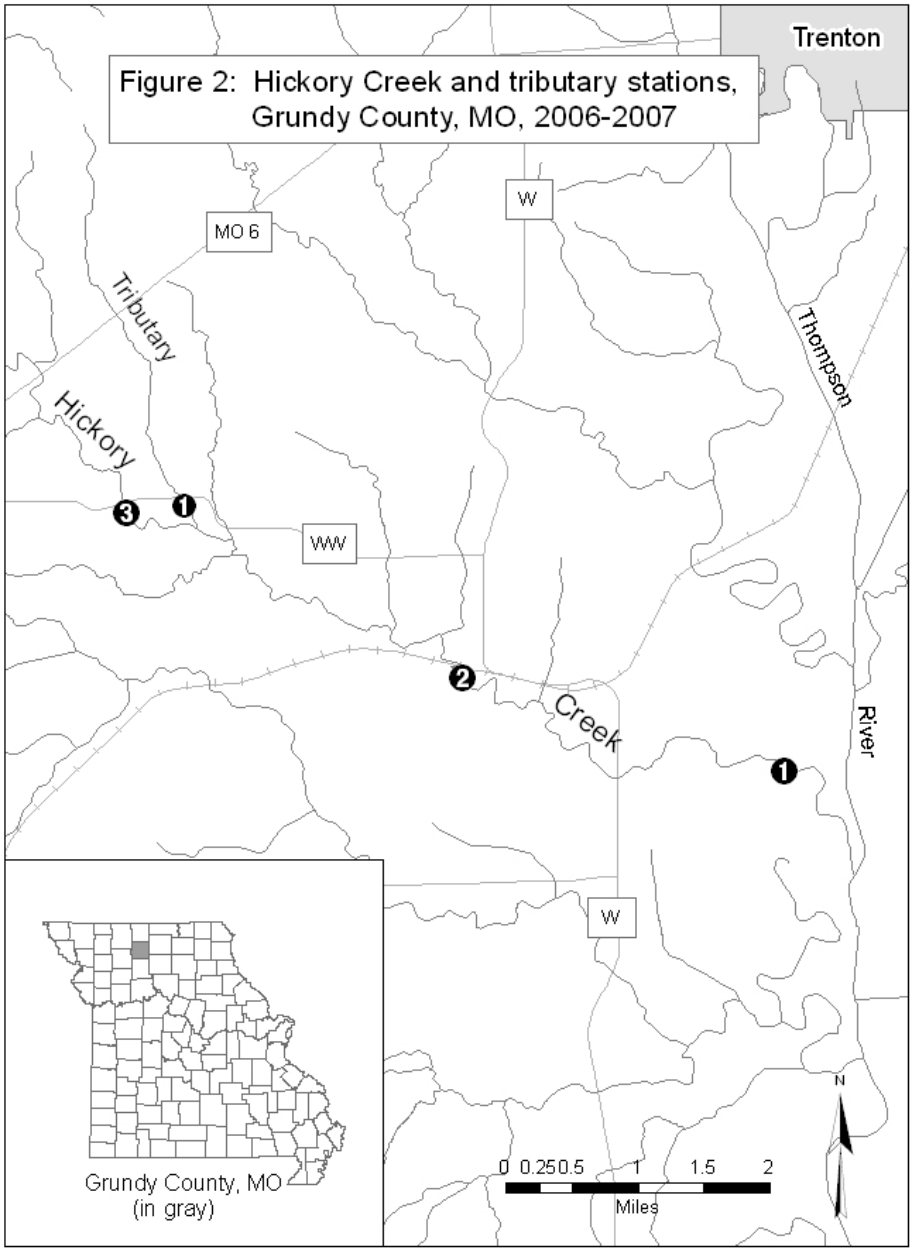
Figure 2: Hickory Creek and tributary stations, Grundy County, MO, 2006-2007
Trenton
W
MO 6
Tributary
Hickory
Thompson
River
WW
Creek
W
N
0 0.250.5 1 1.5 2
Miles
Grundy County, MO
(in gray)

2.2.1 Ecological Drainage Unit

Hickory Creek is located within the Central Plains/Grand/Chariton Ecological Drainage Unit (**EDU**; Figure 1). Ecological Drainage Units are delineated drainage units that are described by the physiographic and major riverine components. Similar size streams within an EDU are expected to contain similar aquatic communities and stream habitat conditions. Comparisons of biological and physicochemical results between test streams and similar size reference streams within the same EDU should then be appropriate

2.2.2 Land Use Description

Land cover was compared between Hickory Creek stations, East Fork Grand River, West Fork Big Creek, and the Central Plains/Grand/Chariton EDU using a 14-digit Hydrological Unit scale (**HUC-14**; Table 2). Percent land cover data were derived from Thematic Mapper satellite data collected between 2000 and 2004 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**).

Land cover was relatively similar between Hickory Creek, Tributary, East Fork Grand River, and West Fork Big Creek stations as well as to the Central Plains/Grand/Chariton EDU (Table 2). All had a relatively high percentage of grassland, but Hickory Creek and Tributary stations had a slightly higher percentage of cropland. General land use should not interfere with comparisons between stations.

Table 2
Percent Land Cover in Hickory Creek, East Fork Grand River, West Fork Big Creek, Hydrologic Units, and the Central Plains/Grand/Chariton EDU

Stations	HUC-14	Urban	Crops	Grass	Forest	Wet	Open
Hickory Creek #3, #2, #1; Tributary	10280102190005	4	36	34	19	3	1
East Fork Grand River #1 (SHAPP only)	10280101060008	0	22	53	19	2	1
West Fork Big Creek #1 (SHAPP only)	10280101150003	1	23	49	21	2	1
Central Plains/ Grand/Chariton EDU	N/A	2	28	45	18	--	--

HUC-14 = 14-digit Hydrologic Unit Code; EDU = Ecological Drainage Unit

2.3 Stream Habitat Assessment Project Procedure

The standardized Stream Habitat Assessment Project Procedure (**SHAPP**) was followed as described for Glide/Pool prevalent streams (MDNR 2003d). According to the SHAPP, the quality of an aquatic community is based on the ability of the stream to support the aquatic community. If SHAPP scores at test stations are ≥75% of the mean control

scores, the stream habitat at the test station is considered to be comparable to the reference (control) stream. East Fork Grand River, Worth County and West Fork Big Creek, Harrison County were used as SHAPP controls (Figure 1). Stream habitat assessment scores were also compared between stations from upstream to downstream.

2.4 Biological Assessment

Sampling was conducted as described in the MDNR Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP,** MDNR 2003c). Biological assessments consisted of macroinvertebrate community and physicochemical water collection and analyses. Macroinvertebrates and physicochemical water variables were analyzed at four stations in Hickory Creek and Tributary, Grundy County.

2.4.1 Macroinvertebrate Sampling and Analyses

Macroinvertebrates were sampled from multiple habitats as described in the SMSBPP (MDNR 2003c). Hickory Creek and Tributary are considered glide/pool dominant streams. As such, non-flowing water over depositional substrate (**NF**), large woody debris (**SG**), and rootmat (**RM**) habitats were sampled.

Macroinvertebrate community data were analyzed using three strategies. Macroinvertebrate Stream Condition Index (**MSCI**) scores, individual biological criteria metrics, and dominant macroinvertebrate families (**DMF**) were examined and compared from upstream to downstream.

A Macroinvertebrate Stream Condition Index is a qualitative rank measurement of a stream's aquatic biological integrity (Rabeni et al. 1997). The MSCI was further refined for reference streams within each EDU in Biological Criteria for Perennial/Wadeable Streams (**BIOREF,** MDNR 2002).

A station's MSCI score is a compilation of rank scores that were assigned to individual biological criteria metrics as a measure of biological integrity. Four primary biological criteria metrics were used to calculate the MSCI per station: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). Metric scores were compared to the BIOREF scoring range (SCI Scoring Table, Tables 4 and 5) and rank scores (5, 3, 1) were assigned to each metric (Tables 4 and 5). For each station, rank scores were compiled from all metrics and the SCI was completed. The SCI scores are interpreted as follows: 20-16 = full biological support; 14-10 = partial biological support; and 8-4 = non-support of the biological community. SCI scores were compared between stations and grouped by season.

Secondly, the individual biological criteria metrics for each station were compared to the BIOREF scoring range to identify the level of integrity for each individual metric. Variations in the metrics may help identify how a community is affected and the potential source of impairment.

The third biological analysis was an evaluation of the "dominant macroinvertebrate families" (**DMF**) per station. The ten most abundant DMF for each station are listed as a percentage of the total number of individuals in the sample. Dominance by certain families may also help identify the type and source of impairment. A taxa list reported by season and station is attached as Appendix A.

2.4.2 Physicochemical Water Sampling and Analyses

Physicochemical water samples were handled according to the appropriate MDNR, ESP Standard Operating Procedures (**SOP**) and/or Project Procedures (**PP**) for sampling and analyzing physicochemical water samples. Results for physicochemical water variables were examined by season and station.

Fall 2006 and spring 2007 physicochemical water parameters consisted of field measurements and grab samples, which were returned to the ESP environmental laboratory. Water was sampled according to the SOP MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2003b). All samples were kept on ice during transport to ESP.

Temperature (C^o), pH, conductivity (uS), dissolved oxygen (mg/L), and discharge (cubic feet per second-**cfs**) were measured *in situ*. The ESP, Chemical Analysis Section in Jefferson City, Missouri conducted analyses for ammonia as nitrogen (mg/L), nitrate+nitrite as nitrogen (**NO_3+NO_2-N;** mg/L), total nitrogen (**TN**; mg/L), chloride (**Cl;** mg/L), and total phosphorus (**TP;** mg/L). Turbidity (**NTU**) was measured and recorded in the WQMS biology laboratory.

Physicochemical water parameters were compared between stations from upstream to downstream as well as with acceptable limits in Missouri's Water Quality Standards (**WQS**, MDNR 2005c). Interpretation of acceptable limits in the WQS may be dependent on a stream's classification and its beneficial-use designation (MDNR 2005c). Hickory Creek is a class C stream, with designated beneficial uses for LWW, AQL, WBC category B. Furthermore, acceptable limits for some parameters may be dependent on the rate of exposure. These exposure or toxicity limits are based on the lethality of a toxicant given long (chronic toxicity, **c**) or short-term exposure (acute toxicity, **a**).

2.4.3 Discharge

Stream discharge was measured using a Marsh-McBirney Flowmate™ flow meter at each station. Velocity and depth measurements were recorded at each station according to SOP MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2003a).

2.5 Channel Measurements

Channel measurements were recorded to illustrate the size and shape of the stream channel and potentially identify past channelization (MDNR 2005a). These measurements included channel width, wetted width, and depth measurements in the channel. Channel measurements were recorded at ten transects per station.

Channel width (**cw**) included the entire channel measured at the top of the lower bank. Wetted width (**ww**) included the channel width that contained water. The depth (**d**) of the stream was measured at three locations (¼, ½, ¾ of the wetted width) in each transect.

Sinuosity is a ratio of the actual stream distance to the straight-line (aerial) distance of the stream. The center of a station was determined on a 7.5-minute topographic map. The actual distance was traced from the center following the stream for one mile upstream and one mile downstream and the actual distance was recorded. Markers were placed at the upstream and downstream end points. The straight-line distance was calculated between these two points. The actual distance was divided by the straight line distance. A sinuosity score of one indicates that the stream is straight. The score increases with increasing sinuosity.

The data were examined for similarities between stations as well as with the control station.

2.6 Quality Control

Quality control was conducted in accordance with MDNR Standard Operating Procedures. Macroinvertebrate community and water physicochemical variables were duplicated at Hickory Creek #1 (e.g. 1a and 1b).

3.0 Results and Analyses

Results are grouped by stream habitat assessment, biological assessment, and channel measurements. Trends and exceptional results are highlighted.

3.1 Stream Habitat Assessment (SHAPP)

The stream habitat in the Hickory Creek stations was comparable to the stream habitat in the control streams (Table 3). Hickory Creek station scores ranged from 111 at station #1 to 115 at station #3. The control scores were 112 and 120, with a mean control score of 116. The percentage of each station's score relative to the mean control ranged from 96 percent of the mean at station #1 to the high of 99 percent at station #3. All percentages were well above 75 percent similarity. Stream habitat was similar at all Hickory Creek stations and comparable to the controls.

Table 3
Stream Habitat Assessment Scores and Percent Comparison for Hickory Creek and Tributary, East Fork Grand River, and West Fork Big River (SHAPP Controls), Fall 2006

	Hickory Creek #3	**Hickory Creek #2**	**Hickory Creek #1**	**East Fork Grand River #1 (Control)**	**West Fork Big River #1 (Control)**
SHAPP Score	115	113	111	120	112
Percent of Mean SHAPP Controls (116)	99	97	96	--	--

3.2 Biological Assessment

Biological assessment consisted of macroinvertebrate community analyses and physicochemical water quality analyses. Results are compared between stations from upstream to downstream.

3.2.1 Macroinvertebrate Community Analyses

The macroinvertebrate community is examined in this section. Macroinvertebrate Stream Condition Index scores, individual metric scores, and dominant macroinvertebrate families are examined from upstream to downstream.

3.2.1.1 Macroinvertebrate Stream Condition Index Scores and Individual Biological Criteria Metrics

Based on the MSCI, all Hickory Creek stations were found to have full support of the biological community in the fall (Table 4). Station #3 had the lowest score of 16, while stations #2 and #1 both had optimum scores of 20.

Individual biological criteria metric scores were not within the optimum BIOREF scoring range at one station in the fall (Table 4). Station #3 had a slightly lower EPTT and slightly higher BI than the optimum range. These may indicate some stress that favors a community that is more tolerant to organic influences or other disturbance. Each of the two individual metrics received a score of 3, along with optimum scores of 5 for TR and SDI, which resulted in station #3 achieving an MSCI score of 16 out of 20. All other stations were represented by individual metrics that were within their respective optimum BIOREF scoring range (Table 4, in light-gray). Despite the indication of a slightly stressed community at Station #3, all Hickory Creek stations fully supported the designated use of AQL in the fall.

Table 4
Fall 2006 Biological Criteria (BIOREF) Metric Scores, Biological Support Category, and MSCI Scores for Hickory Creek, Grundy County

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Hickory Creek #3	0602734	65	**8**	**7.63**	3.25	16	F
Hickory Creek #2	0602735	67	10	7.13	3.23	20	F
Hickory Creek #1	0602741	66	11	6.72	3.21	20	F
BIOREF Score=5	--	>52	>9	<7.18	>2.69	20-16	**F**ull
BIOREF Score=3	--	52-26	9-4	7.18-8.59	2.69-1.34	14-10	**P**artial
BIOREF Score=1	--	<26	<4	>8.59	<1.34	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=17); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

In the spring, MSCI scores indicate that all Hickory Creek stations were fully supporting and Tributary was partially supporting of the designated use of AQL (Table 5). Stations #3 and #2 had scores of 16, while the duplicates #1a and #1b scored 18 and 20, respectively. Tributary had an MSCI score of 12 out of 20.

Individual biological criteria metrics may identify marginal to moderate stress at Hickory Creek and Tributary stations in the spring (Table 5). Station #3 had a marginal EPTT and slightly elevated BI, which caused it to achieve the MSCI score of 16 of 20. Station #2 also had a marginal EPTT and the second highest BI, which also translated to a score of 16 of 20. Station #1 had a marginal BI in the duplicates 1a and 1b, which contributed to MSCI scores of 18 and 20 of 20, respectively. Tributary had a lower than optimum BIOREF scoring range for all four metrics, which gave it a score of 12 of 20. Despite the indication of slightly stressed communities in the spring, all Hickory Creek stations were fully supporting the designated use of AQL, while Tributary was partially supporting.

Table 5
Spring 2007 Biological Criteria (BIOREF) Metric Scores, Biological Support Category, and MSCI Scores for Hickory Creek and Tributary, Grundy County

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	Support
Hickory Creek #3	0703228	71	**8**	**7.40**	2.80	16	F
Hickory Creek #2	0703229	64	**7**	**7.85**	2.90	16	F
Hickory Creek #1a	0703230	65	9	**7.26**	3.10	18	F
Hickory Creek #1b	0703231	61	9	7.07	2.91	20	F
Tributary #1	0703236	**41**	**5**	**8.42**	**1.92**	**12**	**P**
BIOREF Score=5	--	>51	>8	<7.24	>2.53	20-16	**F**ull
BIOREF Score=3	--	51-26	8-4	7.24-8.62	2.53-1.26	14-10	**P**artial
BIOREF Score=1	--	<26	<4	>8.62	<1.26	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF streams (n=21); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.1.2 Dominant Macroinvertebrate Families

Four generally tolerant taxa were among the dominant taxa found in Hickory Creek in the fall (Table 6). Chironomidae was the dominant family, ranging from 40 to 46 percent of the total number of individuals. Caenidae ranged from approximately 13 to 15 percent at the upstream stations before slightly decreasing to 11 percent at station #1. Hyalellidae

was among the dominant taxa at stations #3 and #2, with 11.8 and 1.9 percent, respectively. Tubificidae declined slightly from 6.6 at station #3 to 2.9 at #2 and 3.0 percent at #1.

Table 6
Dominant Macroinvertebrate Families (DMF) as a Percentage of the Total Number of Individuals per Station, Fall 2006

Hickory Creek	**#3**	**#2**	**#1**
Sample Number	0602734	0602735	0602741
Chironomidae	41.0	46.2	40.4
Caenidae	13.1	15.2	11.8
Hyalellidae	11.8	1.9	--
Tubificidae	6.6	2.9	3.0
Coenagrionidae	4.2	--	3.1
Elmidae	3.6	4.7	4.6
Scirtidae	2.9	2.4	2.3
Physidae	2.6	4.5	10.3
Culicidae	2.4	--	--
Baetidae	2.1	--	--
Corixidae	--	4.2	--
Leptophlebiidae	--	2.8	10.6
Arachnoidea	--	2.1	1.6
Sphaeriidae	--	--	3.0

Three generally tolerant families were among the dominant taxa in Hickory Creek in the spring (Table 7). Chironomidae dominated all stations and ranged from 52 to 61 percent. Caenidae was the next dominant taxa at all stations and made up nearly 25 percent at station #3, eight percent at station #2, and 20 percent at station #1. Tubificidae were generally dominant, increasing from approximately 6.3 to 11.1 percent of the total number of individuals from station #3 to station #2. Tubificids decreased again to 6.3 and 1.3 percent at duplicate stations 1a and 1b, respectively.

Tributary was dominated by generally tolerant taxa in the spring (Table 7). Chironomidae comprised nearly 70 percent of the total number of individuals in the sample. Tubificidae made up approximately 6.5 percent of the total number of individuals. Diptera, Enchytraeidae, and Limnephilidae were also among the dominant taxa.

Table 7
Dominant Macroinvertebrate Families (DMF) as a Percentage of the
Total Number of Individuals per Station, Spring 2007

Hickory Creek	**#3**	**#2**	**#1a**	**#1b**	**Tributary**
Sample Number	0703228	0703229	0703230	0703231	0703236
Chironomidae	56.9	61.1	53.0	52.5	69.8
Caenidae	24.7	8.0	13.0	20.9	--
Tubificidae	6.3	11.1	6.4	1.3	6.5
Elmidae	1.6	1.5	3.0	3.6	--
Arachnoidea	1.4	1.6	2.7	2.6	--
Ceratopogonidae	0.9	2.4	1.6	1.0	1.1
Hyalellidae	0.8	--	--	--	--
Coenagrionidae	0.8	--	--	0.9	--
Dytiscidae	0.7	--	--	--	--
Leuctridae	0.7	--	--	--	--
Physidae	--	1.8	--	--	--
Limnephilidae	--	1.8	1.4	--	5.8
Scirtidae	--	1.7	2.1	--	--
Simuliidae	--	1.2	6.7	7.3	1.4
Enchytraeidae	--	--	2.1	1.8	2.9
Perlidae	--	--	--	1.6	--
Diptera	--	--	--	--	5.4
Crangonyctidae	--	--	--	--	1.6
Lymnaeidae	--	--	--	--	0.8
Cambaridae	--	--	--	--	0.6

3.2.2 Physicochemical Water Parameters

Several physicochemical water parameters exhibited interesting trends during the fall 2006 season (Table 8).

The dissolved oxygen concentration was notable at one station in the fall (Table 8). Dissolved oxygen concentrations were above 6.0 mg/L at stations #3 and #1 in the fall, well above the 5.0 mg/L WQS (MDNR 2005c). On September 19, 2006 the dissolved oxygen at station #2 was 1.50 mg/L, well below the WQS of 5.0 mg/L. On September 21, 2006 we returned to station #2 to sample a series of connected pools for dissolved oxygen. The pool near the bridge that was sampled two days previous had a concentration of 0.89 mg/L. A pool approximately 50 yards downstream had a dissolved oxygen concentration of 2.91 mg/L. Approximately 100 yards further downstream, another pool had a dissolved oxygen concentration of 4.24 mg/L. Dissolved oxygen was widely variable depending on locations in the stream.

Flow (discharge) was low in Hickory Creek in the fall (Table 8). No flow was detected at stations #3 and #2. Flow was slightly higher at 0.02 cfs at station #1. Again, Tributary did not have enough water to sample.

Nutrients and chloride were detected at most stations in the fall (Table 8). Total nitrogen was 0.56 mg/L at station #3, increased to 0.64 mg/L at #2, and decreased to 0.32 at #1. Nitrate+nitrite-N was detected at #3 and #1. Total phosphorus was present at all stations ranging from 0.15 mg/L at #3 to 0.07 mg/L at #1. While nutrients were detected, none exceeded WQS (MDNR 2005c).

Table 8
Physicochemical Water Variables for Hickory Creek Stations, Grundy County, Fall 2006

Station Variable- Date	**Hickory Creek #3** 9-19-06	**Hickory Creek #2** 9-19-06	**Hickory Creek #1** 9-21-06
Sample Number	0607282	0607283	0607289
pH (Units)	7.6	7.5	8.0
Temperature (C^0)	14.0	15.0	14.0
Conductivity (uS)	412	384	420
Dissolved O_2	6.19	**1.50**	6.79
Discharge (cfs)	0.00	0.00	0.02
Turbidity (NTUs)	5.24	7.24	14.3
Total Nitrogen	0.56	0.64	0.32
Nitrate+Nitrite-N	0.04	<0.01	0.02
Ammonia-N	<0.03	<0.03	<0.03
Chloride	13.2	9.36	9.89
Total Phosphorus	0.15	0.28	0.07

(Units mg/L unless otherwise noted; **Bold**=Out of WQS acceptable range or trend)

Several water quality parameters were notable in the spring sample (Table 9). Nutrients, chloride, and total phosphorus exhibited interesting trends.

Dissolved oxygen exceeded 7.4 mg/L at all Hickory Creek stations in the spring, well above the 5.0 mg/L WQS (MDNR 2005c). The dissolved oxygen concentration at Tributary was 8.5 mg/L. All dissolved oxygen concentrations were well above the WQS (MDNR 2005c).

Flow increased from upstream to downstream. Flow was 2.27 cfs at station #3 and increased to 3.8 at station #2. Flow increased again to 4.32 cfs at station #1. Flow in Tributary was 0.32 cfs.

Nutrients and chloride were detected in the Hickory Creek spring sample (Table 9). Total nitrogen decreased from 0.41 mg/L at station #3 to 0.39 mg/L at station #2. Total nitrogen decreased again to 0.37 and 0.36 mg/L at duplicates 1a and 1b, respectively. Nitrate+nitrite as nitrogen was detected in station #3 and not detected in the remaining stations. Chloride also appeared to decrease slightly from upstream to downstream.

Total phosphorus increased slightly from upstream to downstream. Concentrations were low and WQS (MDNR 2005b) were not exceeded.

Tributary was similar to Hickory Creek in its composition of nutrients and chloride in the spring (Table 9). Total nitrogen was detected, while nitrate+nitrite-N and ammonia were not detected. Total phosphorus was detected in low concentrations. Chloride was found in similar, low concentrations as were found in Hickory Creek.

Table 9
Physicochemical Water Variables for Hickory Creek and Tributary Stations, Grundy County, Spring 2007

Station	**Hickory Creek #3**	**Hickory Creek #2**	**Hickory Creek #1a**	**Hickory Creek #1b**	**Tributary**
Variable/ Date	3-27-07	3-27-07	3-27-07	3-27-07	3-28-07
Sample Number	0704028	0704029	0704030	0704031	0704036
pH (Units)	7.7	7.9	7.9	--	7.9
Temperature (C^0)	15.5	16.0	17.0	--	17.5
Conductivity (uS)	540	503	505	--	546
Dissolved O_2	7.42	7.47	7.45	--	8.50
Discharge (cfs)	2.27	3.80	4.32	--	0.32
Turbidity (NTUs)	3.97	4.75	5.98	5.39	2.25
Total Nitrogen	0.41	0.39	0.37	0.36	0.31
Nitrate+Nitrite-N	0.03	<0.01	<0.01	<0.01	<0.01
Ammonia-N	<0.03	<0.03	<0.03	<0.03	<0.03
Chloride	22.0	17.1	16.1	16.2	14.9
Total Phosphorus	0.04	0.06	0.07	0.08	0.05

(Units mg/L unless otherwise noted; **Bold**=Out of WQS acceptable range or trend; 1a and 1b= QC Duplicates)

3.3 Channel Measurements

Channel measurements were recorded at all Hickory Creek stations, both controls, and estimated for Tributary (Table 10). The control streams were slightly larger than Hickory Creek and Tributary, so some comparisons may not be appropriate. Ratios, standard deviation of depth, and sinuosity may be more reliable measures for longitudinal comparisons.

The most notable findings were that the upstream station (#3) was wider and deeper than downstream stations (Table 10). The stream was shallower overall downstream at station #1. The standard deviation of depth was similar to the controls, yet slightly less variable downstream at station #1. Sinuosity was similar from upstream to downstream and to the controls.

Table 10
Channel Measurement Information for Hickory Creek, Tributary, East Fork Grand River, and West Fork Big Creek Stations

STATION VARIABLE	**Hickory Creek #3**	**Hickory Creek #2**	**Hickory Creek #1**	**Tributary**	**East Fork Grand River #1**	**West Fork Big Creek #1**
Channel Width Average (**cw**)	24.8	19.7	18.4	6.0 est.	57.0	34.9
Wetted Width Average (**ww**)	21.5	17.4	11.5	1.5 est.	40.30	22.45
Cw/ww	1.15	1.13	1.60	4.0 est.	1.41	1.55
ww/d	17.81	24.03	35.01	3.0 est.	57.96	24.99
Depth Average (**d**)	1.21	0.72	0.33	0.5 est.	0.7	0.90
Depth Standard Dev.	0.64	0.47	0.25	--	0.49	0.50
Maximum Depth	2.75	1.75	0.92	1.0 est.	1.97	2.15
*Sinuosity	1.33	1.55	1.33	1.19	1.48	1.73
Sinuosity (Actual) Length	3177	3268	3192	3131	3145	3377

* Sinuosity=Actual vs. Straight Line Distance Ratio; Units=feet; est.=estimated

4.0 Discussion

The discussion is arranged by Hickory Creek and Tributary. Stream habitat is assessed. Results of the biological assessment, which includes macroinvertebrate and water quality, are discussed. Channelization measurements are examined.

4.1 Hickory Creek Stations

All Hickory Creek stations fully supported the biological community during both seasons. However, some stress was observed related to the stream habitat, macroinvertebrate community, water quality, and channel measurements.

4.1.1 Stream Habitat

Stream habitat scores indicated that all Hickory Creek stations are comparable to the reference stations for the Central Plains/Grand/Chariton EDU. General observations show that the substrate was sandy at #3 with beaver influence. Substrate at station #2 was muddy with dark stained water, probably due to local erosion of stream banks or upstream cattle influence. Station #1 had a very sandy bottom with mostly shallow water depths. This was probably due to deposition from upstream influences and a lessening

gradient at station #1 near the confluence with the Thompson River. Stream banks were moderately stable to stable throughout the study area with some localized areas of erosion.

4.1.2 Macroinvertebrate Community Integrity

All stations on Hickory Creek were found to fully support the biological community during both seasons. However, some stress was indicated by less than optimum metrics at station #3 in the fall and all three stations in the spring. In the fall #3 had fewer EPTT and a slightly elevated BI. Very low flow and beaver influence may have altered the community. Influence may also have been present upstream. In the spring all stations had slightly elevated BI values while #3 and #2 had fewer EPTT than the optimum. The community structure appeared to recover somewhat downstream at station #1 in the spring, suggesting that the influence was not as dominant at that station. These trends suggest that the influence was: 1) upstream or within station #3; 2) not continuous; 3) probably related to runoff.

4.1.3 Water Quality

Water quality was not similar between fall and spring. Flow and dissolved oxygen were significantly lower in the fall than in the spring. Dissolved oxygen was below WQS (5.0 mg/L) at station #2 in the fall and well above WQS at all stations in the spring. Nutrients and chlorides were detected in the fall and spring at similar concentrations. The presence of nutrients suggests some input throughout or upstream of the study area. Water samples should be collected to examine effects of precipitation related runoff for Hickory Creek. A suspended sediment study should be conducted on Hickory Creek stations.

4.1.4 Channelization Assessment

It is generally thought that channelized streams have less variation in depth and generally more homogenous habitat, which may not support a high quality macroinvertebrate community (AFS 1971; MDNR 2005a). Channelized streams are said to be straighter, wider, and shallower with less variation in depth (MDNR 2005a).

Hickory Creek exhibited some channelization characteristics using our channel measurements. The stream was not straighter than the control streams as would be expected if the stream was channelized. Wetted widths were slightly wider upstream, due in part to damming created by beaver activity at #3, not due to channelization. Wetted width would have been similar during normal flow without that influence, as is shown by similar channel widths from upstream to downstream. The stream was shallower downstream in station #1 with less variation in depth. Station #1 is near the confluence with the Thompson River which may have an effect on deposition of fine material and which may originate from upstream Hickory Creek land use. While the stream exhibited some effects of channelization, these effects are not exclusive of channelization. Land use upstream is a more likely contributor of the fine sediment. No channelization was evident, other than near bridge pools, or has been recorded in the past (NRCS 2005). Channelization did not have an obvious affect on stream habitat quality.

4.2 Tributary Station

Stream habitat was not assessed at Tributary in the spring because it would not be an appropriate comparison to the fall assessments conducted on the controls. However general comments were recorded. Hickory Creek Tributary partially supported the macroinvertebrate community during sampling in the spring of 2007. Water quality parameters did not obviously identify a cause for impairment. Channel measurements did not suggest that channelization impaired the stream.

4.2.1 Stream Habitat

Stream habitat general observations were recorded at Tributary (Appendix B). A sand lens was present in the stream, identifying movement of heavy benthic fine sediment deposits. This may have been a result of recent bank stabilization near highway WW, runoff in the watershed upstream, or local bank erosion. Stream banks were moderately unstable in Tributary. A benthic sediment study may provide distribution and relative measurements.

4.2.2 Macroinvertebrate Community Integrity

The macroinvertebrate community partially supported the biological community in the spring of 2007. Tributary had an SCI score of 12. No metrics (TR, EPTT, BI, SDI) reached the optimum BIOREF scoring range. Dominant macroinvertebrate families included generally tolerant Chironomidae, Tubificidae, Ceratopogonidae, Enchytriadae, and Limnephilidae. The Limnephilidae taxon was *Ironoquia*, which is very tolerant to organic pollution. Overall, the macroinvertebrate community at this station appeared to be tolerant to disturbance and organic influences. Biological assessments should be conducted on other intermittent streams within this EDU to evaluate criteria and identify reference metrics associated with intermittent streams.

4.2.3 Water Quality

Water quality parameters did not identify a source for impairment of Tributary. Nutrients and chloride were detected in low levels, similar to Hickory Creek stations but probably fluctuating during runoff. During the fall, there was very little habitat or water and Tributary could not be sampled. In the spring, Tributary was flowing and had sufficient habitat to be adequately sampled. Tributary is intermittent, which may be the reason for the community structure of tolerant organisms. There was also some road work that had been conducted upstream of the Tributary sample station on highway WW which may have altered the community structure (Appendix B photos). Water samples should be collected to examine effects of precipitation related runoff for Tributary. A suspended sediment study should be conducted on Tributary.

4.2.4 Channelization Assessment

Tributary was not channelized beyond possible bridge effect channelization (Appendix B). Tributary was much smaller than Hickory Creek and the control streams. Results show that Tributary is slightly straighter than the controls; however, this may be a function of the resolution of the sinuosity calculations. Tributary appears to be less sinuous on maps than it actually was in the field, because of its size. The depth was

similar to downstream Hickory Creek and also contained heavy benthic fine sediment. Again, the stream bank was recently stabilized upstream from the Tributary station, which may have been responsible for the benthic sediment.

5.0 Conclusion

The purpose of this project was to determine if Hickory Creek and/or Tributary were impaired. Hickory Creek was not impaired during the study. Tributary was impaired during the study.

The objectives were achieved. 1) The stream habitat quality was assessed for Hickory Creek; 2) the macroinvertebrate community integrity and water quality were assessed for Hickory Creek and Tributary; 3) Hickory Creek and Tributary exhibit some channelization characteristics, however, were not channelized beyond bridge effects.

The following hypotheses were examined: 1) Stream habitat is similar between stations of Hickory Creek from upstream to downstream and with the controls; 2a) macroinvertebrate communities were similar between reaches of Hickory Creek from upstream to downstream and to the BIOREF scoring range, while; 2b) the community at Tributary was not similar to Hickory Creek or within the BIOREF optimum scoring range; 3a) Hickory Creek water quality was not similar from upstream to downstream in the fall, as station #2 dissolved oxygen concentration was not within acceptable water quality standards (MDNR 2005c), however, all parameters were similar and acceptable in the spring; 3b) water quality in Tributary was similar to Hickory Creek and within acceptable WQS limits in the spring; 4) channel morphology differed slightly from upstream to downstream, however, channelization was not the apparent contributor.

6.0 Recommendations:

1) Biological assessments should be conducted on other intermittent streams within this EDU to evaluate criteria and identify reference metrics associated with intermittent streams.

2) Water samples should be collected to examine effects of precipitation related runoff for Hickory Creek and Tributary.

3) A suspended sediment study should be conducted on Hickory Creek and Tributary.

4) A suspended sediment study should be conducted on Tributary.

7.0 Literature Cited

American Fisheries Society (AFS). 1971. Stream channelization, a symposium. E. Schneberger and J. Funk Eds. North Central Division, American Fisheries Society, Special Publication No. 2. 33rd Midwest Fish and Wildlife Conference. Omaha, Nebraska. 83 pp.

Missouri Department of Conservation (MDC). 2008. Grand River Watershed Management Plan. Greg Pitchford, Harold Kerns Northwest Regional Fisheries, 701 NE College Drive, St. Joseph, Missouri 64507. http://mdc.mo.gov/fish/watershed/grand/contents/

Missouri Department of Natural Resources (MDNR). 2002. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources (MDNR). 2003a. Flow measurements in open channels. Water Quality Monitoring Section-113. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 9 pp.

Missouri Department of Natural Resources (MDNR). 2003b. Required/recommended containers, volumes, preservatives, holding times, and special sampling considerations. Field Services Section-001. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 25 pp.

Missouri Department of Natural Resources (MDNR). 2003c. Semi-quantitative macroinvertebrate stream bioassessment project procedure. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 24 pp.

Missouri Department of Natural Resources (MDNR). 2003d. Stream habitat assessment project procedure. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 40 pp.

Missouri Department of Natural Resources (MDNR). 2004. Missouri 2002 303(d) list (modified) – May 2004. P.O. Box 176, Jefferson City, Missouri 65102-0176.

Missouri Department of Natural Resources (MDNR). 2005a. Channel modification analyses of streams listed on the 303(d) list for sediment from non-point source agriculture 2002-2004. Water Quality Monitoring Section, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 7 pp. + Appendices

Missouri Department of Natural Resources (MDNR). 2005b. Taxonomic levels for macroinvertebrate identifications. Water Quality Monitoring Section-209. Environmental Services Program, P.O. Box 176, Jefferson City, Missouri. 30 pp.

Missouri Department of Natural Resources MDNR). 2005c. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. pp. 10-136.

Natural Resources Conservation Service (NRCS). 2005. Grundy County Hickory Creek Watershed Project. Agricultural Nonpoint (AgNPS) Source, Special Area Land Treatment (SALT) Grant Application to the Missouri Department of Natural Resources, Soil and Water Conservation Program.

Rabeni, C.F., R.J. Sarver, N. Wang, G.S. Wallace, M. Weiland, and J.T. Peterson. 1997. Biological criteria for streams of Missouri. Missouri Cooperative Fish and Wildlife Research Unit, University of Missouri-Columbia, Columbia, Missouri. 261 pp.

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Appendix A

Macroinvertebrate Bench Sheet Report for Hickory Creek and Hickory Creek Tributary Stations
Fall 2006 and Spring 2007

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602734], Station #3, Sample Date: 9/19/2006 11:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	8		2
AMPHIPODA			
Hyalella azteca	1	102	23
COLEOPTERA			
Berosus	1		
Dubiraphia	17	19	1
Gyrinus		1	1
Peltodytes		3	1
Scirtidae	1	30	
Stenelmis	1		1
DIPTERA			
Ablabesmyia	2	10	4
Allognosta		1	
Anopheles	1	13	
Ceratopogoninae	15		
Chaoborus	3		
Chironomus	8		2
Cladotanytarsus	19		16
Cryptochironomus	4		
Culex		12	
Dicrotendipes	10	9	64
Endochironomus		2	
Forcipomyiinae			1
Glyptotendipes	3	33	86
Labrundinia		9	3
Parachironomus	3	10	1
Paracladopelma	2		1
Paratanytarsus	2	18	3
Phaenopsectra		3	
Polypedilum fallax grp		1	
Polypedilum halterale grp	8		
Polypedilum illinoense grp		9	2
Procladius	10	1	1
Pseudosmittia			1
Stenochironomus			5
Stictochironomus	8		
Stratiomys		1	
Tabanus		3	
Tanypus	1		1
Tanytarsus	17	11	32

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602734], Station #3, Sample Date: 9/19/2006 11:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Thienemannimyia grp.			2
EPHEMEROPTERA			
Caenis latipennis	66	9	65
Callibaetis		3	
Hexagenia limbata	6		
Leptophlebiidae		12	2
Procloeon	2	5	13
Stenonema femoratum		1	5
HEMIPTERA			
Corixidae	9		
Neoplea		1	
Palmacorixa		1	
Rheumatobates		2	
Trepobates		1	
LIMNOPHILA			
Lymnaeidae		1	
Physella	5	18	5
MEGALOPTERA			
Sialis	-99		
ODONATA			
Argia		9	2
Dromogomphus	-99		
Enallagma		15	
Ischnura		19	
Somatochlora	-99		
TRICHOPTERA			
Oecetis			2
Triaenodes		4	
TRICLADIDA			
Planariidae		1	
TUBIFICIDA			
Aulodrilus	34		
Enchytraeidae			1
Limnodrilus cervix	1		
Tubificidae	32	3	1
VENEROIDEA			
Sphaeriidae	6	-99	3

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602735], Station #2, Sample Date: 9/19/2006 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
N/A			
Chordodidae		1	
"HYDRACARINA"			
Acarina	9	8	5
AMPHIPODA			
Hyalella azteca		20	
ARHYNCHOBDELLIDA			
Erpobdellidae	2		
COLEOPTERA			
Berosus		2	
Coleoptera		1	
Dubiraphia	6	39	4
Helichus lithophilus		3	1
Neoporus		4	
Paracymus	1	1	
Scirtidae	1	24	
DECAPODA			
Orconectes virilis	-99		
DIPTERA			
Ablabesmyia	6	8	1
Anopheles		1	1
Axarus	5		
Ceratopogoninae	5	1	1
Chironomus	47	6	2
Chrysops		1	
Cladotanytarsus	59	1	10
Cryptochironomus	8		
Cryptotendipes	6		
Culex	1	4	2
Dicrotendipes	6	18	133
Diptera	1	1	1
Glyptotendipes		8	15
Labrundinia	1		1
Parachironomus		4	
Parakiefferiella	1		
Paratanytarsus		2	1
Phaenopsectra	1	1	1
Polypedilum fallax grp			1
Polypedilum halterale grp	10	7	
Polypedilum illinoense grp		3	2

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602735], Station #2, Sample Date: 9/19/2006 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Procladius	11	2	1
Stenochironomus			12
Stictochironomus	5		
Tanytarsus	30	7	22
Thienemannimyia grp.		5	4
Tribelos			6
EPHEMEROPTERA			
Caenis latipennis	62	33	63
Callibaetis	1		1
Hexagenia limbata	11		2
Leptophlebiidae		18	12
Procloeon	7	1	
Stenacron		2	3
Stenonema femoratum	1		2
HEMIPTERA			
Corixidae	31	3	5
Microvelia		4	
Trepobates		1	
Trichocorixa	5		
LIMNOPHILA			
Ancylidae		3	1
Lymnaeidae		4	
Physella	6	36	5
MEGALOPTERA			
Sialis	-99	-99	
ODONATA			
Argia		11	3
Dromogomphus	-99		
Enallagma	-99	3	
Libellula		-99	
Progomphus obscurus	-99		
Somatochlora	3		
RHYNCHOBDELLIDA			
Glossiphoniidae		1	
TRICHOPTERA			
Oecetis	6		
Ptilostomis		2	
Triaenodes		4	
TUBIFICIDA			
Aulodrilus			2

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602735], Station #2, Sample Date: 9/19/2006 2:00:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Tubificidae	12	14	3
VENEROIDEA			
Sphaeriidae	9	9	

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602741], Station #1, Sample Date: 9/21/2006 8:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
N/A			
Gordiidae	1		
"HYDRACARINA"			
Acarina	6	11	1
AMPHIPODA			
Hyalella azteca	1	8	1
COLEOPTERA			
Dubiraphia	5	34	11
Helichus lithophilus		4	
Scirtidae		10	16
Stenelmis		1	
Tropisternus	2	1	
DIPTERA			
Ablabesmyia	3		2
Ceratopogoninae	7		2
Chironomus	2		7
Chrysops			1
Cladotanytarsus	22		2
Clinotanypus		2	
Corynoneura			1
Cryptochironomus	18		
Cryptotendipes	2	2	
Dicrotendipes	8	2	98
Forcipomyiinae			1
Glyptotendipes			11
Gonomyia	1		
Labrundinia	1	5	1
Microtendipes			1
Nanocladius	1		
Nilothauma			1
Paracladopelma	1		
Parakiefferiella			4
Paratanytarsus			1
Phaenopsectra			2
Polypedilum fallax grp			2
Polypedilum halterale grp	71	3	
Polypedilum illinoense grp	6	3	5
Polypedilum scalaenum grp			2
Procladius	5	2	4
Rheotanytarsus			1

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0602741], Station #1, Sample Date: 9/21/2006 8:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Stempellinella	6		
Stenochironomus			36
Stictochironomus	5		
Tanytarsus	32	5	32
Thienemannimyia grp.		2	17
Tribelos			4
undescribed Empididae		1	
EPHEMEROPTERA			
Brachycercus	1		
Caenis latipennis	66	12	51
Hexagenia	11	1	1
Leptophlebiidae		96	21
Procloeon	2	2	7
Stenacron			6
Stenonema femoratum			2
HEMIPTERA			
Microvelia			1
Trepobates	1	2	
LIMNOPHILA			
Lymnaeidae	1	3	
Physella	1	110	2
MEGALOPTERA			
Sialis	1		1
ODONATA			
Argia		23	5
Enallagma		7	
Gomphus	-99		
Progomphus obscurus	-99		
TRICHOPTERA			
Cheumatopsyche			1
Nyctiophylax	1		10
Oecetis	6		1
Triaenodes		3	
TUBIFICIDA			
Aulodrilus	4	5	
Ilyodrilus templetoni	1		
Tubificidae	16	7	
VENEROIDEA			
Sphaeriidae	7	24	2

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703228], Station #3, Sample Date: 3/27/2007 9:00:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	11	1	
AMPHIPODA			
Crangonyx	1		
Hyalella azteca		7	
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
COLEOPTERA			
Dubiraphia	9	3	
Helichus basalis		1	1
Helichus lithophilus		1	
Neoporus	3	2	1
Paracymus			1
Scirtidae		1	
Stenelmis	2		
DIPTERA			
Ablabesmyia	14	9	
Ceratopogoninae	5	1	1
Chironomus	4		1
Chrysops	1		
Cladotanytarsus	15		1
Corynoneura	1		
Cricotopus/Orthocladius	17	72	99
Cryptotendipes	2		
Dasyheleinae	1		
Dicrotendipes	5	2	12
Glyptotendipes	2	5	6
Hydrobaenus	30	34	35
Kiefferulus	1		
Microtendipes	2		
Nanocladius			1
Natarsia	1		
Paracladopelma	2		
Paraphaenocladius	1	4	
Paratanytarsus		16	4
Paratendipes	2	1	
Pericoma	1		
Phaenopsectra	2	2	
Polypedilum convictum		1	2
Polypedilum halterale grp	5		

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703228], Station #3, Sample Date: 3/27/2007 9:00:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Polypedilum illinoense grp	2	2	2
Polypedilum scalaenum grp	2		
Procladius	3		
Pseudosmittia	1		
Psychoda	1		1
Saetheria	1		
Simulium	1		2
Stictochironomus	18		
Tabanus		-99	
Tanytarsus	12	10	7
Thienemanniella		1	
Thienemannimyia grp.		3	2
Zavrelimyia	5	1	
EPHEMEROPTERA			
Caenis latipennis	75	136	
Heptageniidae	1	1	
Leptophlebia	-99	3	
Stenonema femoratum	-99	1	1
LIMNOPHILA			
Physella	1	1	2
ODONATA			
Argia	1	1	
Calopteryx		1	
Enallagma	1	3	
Gomphus	1		
Ischnura	1		
Libellula	2	-99	-99
Progomphus obscurus	-99		
Tetragoneuria	1		
PLECOPTERA			
Leuctridae	6		
Perlesta		3	1
TRICHOPTERA			
Ironoquia		2	
Ptilostomis		1	1
TUBIFICIDA			
Enchytraeidae	1	1	
Limnodrilus claparedianus	7		
Limnodrilus hoffmeisteri	19	3	
Tubificidae	23	2	
VENEROIDEA			

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703228], Station #3, Sample Date: 3/27/2007 9:00:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Corbicula	1		
Sphaeriidae	2	-99	

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703229], Station #2, Sample Date: 3/27/2007 10:10:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	4	8	4
AMPHIPODA			
Crangonyx		2	
Hyalella azteca	1	7	
COLEOPTERA			
Dubiraphia	8	5	2
Enochrus			1
Neoporus		1	
Peltodytes	1		2
Scirtidae		17	
DIPTERA			
Ablabesmyia	3	7	7
Ceratopogoninae	21	2	1
Chironomus	3		
Cladotanytarsus	9		1
Cricotopus/Orthocladius	3	52	51
Cryptotendipes	20		
Dicrotendipes	2	3	21
Diptera		1	2
Dolichopodidae	1		
Glyptotendipes			7
Hydrobaenus	47	63	146
Labrundinia		1	2
Limnophyes			1
Nanocladius		2	
Parachironomus			1
Paraphaenocladius		1	4
Paratanytarsus		1	
Pericoma	1		
Phaenopsectra		1	
Pilaria		1	1
Polypedilum convictum	1	5	
Polypedilum halterale grp	1		
Polypedilum illinoense grp		29	1
Procladius	14		
Simulium		12	
Stenochironomus			3
Stictochironomus	5		1
Stratiomys		2	1

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703229], Station #2, Sample Date: 3/27/2007 10:10:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Tabanus			-99
Tanytarsus	40	19	17
Thienemanniella			1
Thienemannimyia grp.		1	2
Tipulidae			-99
EPHEMEROPTERA			
Caenis latipennis	48	6	25
Hexagenia limbata	1		
Leptophlebia		2	
Stenacron	1		
Stenonema femoratum			1
HEMIPTERA			
Belostoma		-99	
Microvelia		5	
Trichocorixa	7	1	2
LIMNOPHILA			
Ancylidae			2
Fossaria	1	3	3
Physella	5	10	3
ODONATA			
Argia			1
Dromogomphus	-99		
Gomphidae		1	
Nasiaeschna pentacantha		-99	
Plathemis	1	1	
PLECOPTERA			
Perlesta		4	2
TRICHOPTERA			
Ironoquia		18	
TRICLADIDA			
Planariidae		1	
TUBIFICIDA			
Limnodrilus claparedianus	7		
Limnodrilus hoffmeisteri	11		
Tubificidae	73	12	6
VENEROIDEA			
Sphaeriidae	5	2	

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703230], Station #1a, Sample Date: 3/27/2007 11:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	7	17	1
AMPHIPODA			
Hyalella azteca		1	
COLEOPTERA			
Dubiraphia	3	21	4
Helichus lithophilus		8	
Hydroporus	4	2	
Scirtidae		20	
DECAPODA			
Orconectes virilis	1		
Palaemonetes kadiakensis		-99	
DIPTERA			
Ablabesmyia	14	6	
Ceratopogoninae	9	6	
Chironomus	5		
Chrysops	3	2	
Cladotanytarsus	6	1	
Cricotopus/Orthocladius	31	36	58
Cryptochironomus		1	
Cryptotendipes	3	2	
Diamesa	1		
Dicrotendipes	1	2	38
Diptera	2		3
Glyptotendipes		2	2
Hydrobaenus	87	34	16
Labrundinia	1	7	
Nilothauma			1
Paraphaenocladius	4	3	2
Paratanytarsus	1	7	1
Paratendipes	2		
Pericoma	1		
Phaenopsectra	2		
Polypedilum fallax grp			2
Polypedilum halterale grp	6		
Polypedilum illinoense grp		1	1
Polypedilum scalaenum grp		1	1
Procladius	2		
Saetheria	1		
Simulium	1	3	58

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703230], Station #1a, Sample Date: 3/27/2007 11:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Stenochironomus			2
Stictochironomus	35		1
Tabanus		-99	
Tanytarsus	12	20	15
Thienemannimyia grp.		4	6
Tipula	1		
EPHEMEROPTERA			
Caenis latipennis	38	61	21
Hexagenia limbata	1		
Leptophlebia	7		
Stenacron	1		
HEMIPTERA			
Microvelia		1	
LIMNOPHILA			
Fossaria	3	2	
Physella		3	
ODONATA			
Argia		2	
Calopteryx		1	
Enallagma		3	
Gomphus	-99		
Libellula		1	
Progomphus obscurus	2		
PLECOPTERA			
Perlesta	1	1	
TRICHOPTERA			
Cheumatopsyche		1	1
Ironoquia	2	11	
Oecetis	1	1	
Triaenodes		4	
TUBIFICIDA			
Aulodrilus	3	4	
Enchytraeidae	11	3	6
Limnodrilus claparedianus	2		
Limnodrilus hoffmeisteri	4	3	
Tubificidae	29	13	1
VENEROIDEA			
Sphaeriidae	2	2	

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703231], Station #1b, Sample Date: 3/27/2007 11:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	11	9	2
COLEOPTERA			
Dubiraphia	4	20	6
Helichus lithophilus		3	
Neoporus		1	
Paracymus			1
Scirtidae		4	
Tropisternus		-99	
DIPTERA			
Ablabesmyia	5	5	
Ceratopogoninae	5	2	2
Chironomus	3		
Chrysops	1		
Cladotanytarsus	10	1	6
Clinotanypus	1		
Cricotopus/Orthocladius	28	27	48
Cryptochironomus	2		
Cryptotendipes	6	1	
Dicrotendipes		3	31
Diptera	2		1
Glyptotendipes			3
Hydrobaenus	70	32	25
Labrundinia		1	2
Nanocladius	1		
Nilothauma			1
Paracladopelma	1		
Paraphaenocladius	7	1	2
Paratanytarsus		4	1
Pericoma		1	
Phaenopsectra		2	
Polypedilum convictum	1		
Polypedilum fallax grp			1
Polypedilum halterale grp	5		
Polypedilum illinoense grp	1	1	2
Procladius	5		
Simulium	1	4	56
Smittia	1		
Stenochironomus			4
Stictochironomus	22		

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck [0703231], Station #1b, Sample Date: 3/27/2007 11:30:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Tanytarsus	14	17	17
Thienemanniella			2
Thienemannimyia grp.		10	3
EPHEMEROPTERA			
Caenis latipennis	28	125	21
Heptageniidae	1		
Hexagenia limbata	2		
Leptophlebia	1	1	2
HEMIPTERA			
Microvelia			1
Trichocorixa	2		1
LIMNOPHILA			
Lymnaeidae	3		
Physella	2	3	
ODONATA			
Argia		6	
Calopteryx		2	
Enallagma		2	
Progomphus obscurus	1		
PLECOPTERA			
Perlesta	3	6	5
TRICHOPTERA			
Ironoquia	1	3	1
Oecetis			1
Ptilostomis		-99	
Triaenodes	1		
TUBIFICIDA			
Enchytraeidae	5	4	6
Limnodrilus hoffmeisteri	2		
Tubificidae	6	3	
VENEROIDEA			
Sphaeriidae	5	1	1

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck Trib. [0703236], Station #1, Sample Date: 3/28/2007 12:15:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Crangonyx	1	11	1
COLEOPTERA			
Agabus		1	
Helichus lithophilus			2
DECAPODA			
Orconectes immunis	3	2	-99
DIPTERA			
Ablabesmyia		1	
Ceratopogoninae	8		1
Chrysops	-99		
Cladotanytarsus	2		
Cnephia	1		
Cricotopus/Orthocladius	43	67	56
Diamesa	1		
Dicrotendipes		1	
Diptera	7	34	3
Ephydridae		1	
Glyptotendipes	2	1	1
Gonomyia		1	
Hydrobaenus	186	146	54
Limnophyes		2	
Ormosia			1
Paraphaenocladius		1	
Pericoma			1
Simulium		5	3
Stegopterna	1		2
Stratiomyidae	1		
Tipula			1
EPHEMEROPTERA			
Caenis latipennis		1	
Leptophlebiidae	2	2	1
HEMIPTERA			
Trichocorixa		1	
LIMNOPHILA			
Fossaria	2	4	1
Physella	-99	3	1
LUMBRICULIDA			
Lumbriculidae	1		1
PLECOPTERA			

Aquid Invertebrate Database Bench Sheet Report
Hickory Ck Trib. [0703236], Station #1, Sample Date: 3/28/2007 12:15:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Perlesta		1	
TRICHOPTERA			
Ironoquia	7	35	5
Ptilostomis		1	
TRICLADIDA			
Planariidae		2	
TUBIFICIDA			
Enchytraeidae	6	13	5
Limnodrilus claparedianus		1	
Limnodrilus hoffmeisteri	5	2	
Tasserkidrilus superiorensis	6	1	1
Tubificidae	34	2	1
VENEROIDEA			
Sphaeriidae	4		

Appendix B

Photographs of Hickory Creek Tributary at Highway WW
Grundy County

Hickory Creek Tributary Station #1, Grundy County: Downstream (south) highway WW.

Hickory Creek Tributary, Grundy County: Upstream (north) highway WW. Note: Size and recent stream bank stabilization on east side (right) of stream.